Volume 30 March, 1944 *Number 3*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Construction
Machinery

PUBLISHED BY
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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Construction Machinery

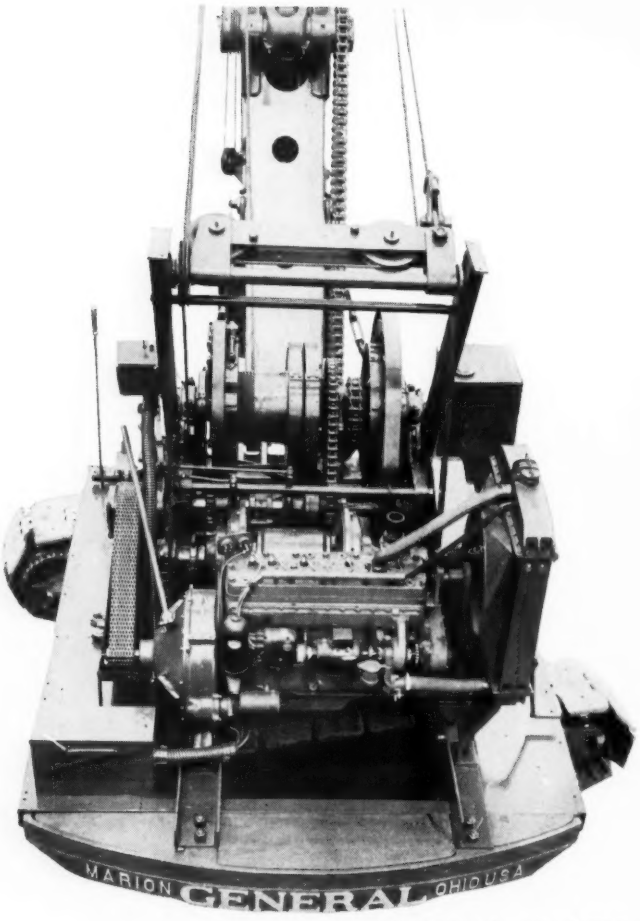
RECONSTRUCTION becomes necessary after a period of demolition, whether structures, highways or airport runways have been demolished by military activities, or purposely to prepare for new construction. Reconstruction will continue to be a major objective for a considerable period in the European war areas; there it will probably be the primary objective. Quite naturally it will involve heavy duty machinery some of which—the bulldozer for example—has so aptly proved its value as a means of moving great volumes of earth, rubble and tangled steel reinforcing materials.

To the casual observer who might not be aware of the cause, the results of demolition appear to be very similar. A concrete or masonry building being razed for highway extension purposes looks much the same as the aftermath of a bombing raid. A concrete bridge being torn out to permit installing a new span is not much different than a bridge of like nature which has been mined and blown up by military engineers.

Just as the results are very much the same, so are the means of reconstruction — only in war, reconstruction must be carried out with greater speed, sacrificing appearance in favor of utility value. The strength, however, must be comparable; bridges must carry the heaviest tanks as well as fully loaded trailer trucks; building floors must carry maximum storage loads; walls must resist the force resulting from bomb explosion; roofs must carry the prevailing snow loads.

HIGHWAYS have been an essential in peace and war ever since the Exodus. From the war chariot to the tank is quite a transition; equally so from the ox-drawn forage cart to the modern truck. Our National system of highways naturally was extended to meet transportation demands. From some 1800 miles of post roads during the American Revolution to our 3,000,000 miles of roads and highways today is evidence of how we have combined the means of getting there with the way of getting there.

And now the airways require additional surfaced areas for take-off and landing. Coupled with all this are the accessory bridges, culverts and buildings. Furthermore, all must be subject to a continual course of modernization. In wartime combat areas this means double-speed reconstruction. In peace it will require a greater expansion program than ever before when the public begins to roll again.



Courtesy of The General Excavator Company

Fig. 1—The machinery deck of a General shovel. All high-speed parts operate in anti-friction bearings. The first reduction is through an adjustable silent chain.

THE MACHINERY AVAILABLE

The machinery which predominates in construction or reconstruction in the progressive order of utility, includes the bulldozer, power shovel, trenching machine, backfiller, concrete mixer, concrete pump, the hoist or elevator, the road roller and the belt conveyor. The extent to which any one may be used depends upon the nature of the job. The bulldozer is a key machine in leveling bomb craters on an airport runway. The belt conveyor is vital on large earth moving jobs such as dam construction work.

The internal combustion engine is the most widely used power plant in mobile machinery such as the bulldozer and power shovel, especially in military service. In public works or industrial service, however, fuel availability may render steam power most adaptable.

The high speed Diesel and heavy duty gasoline engine are both ideally suited to the bruising service involved. In reality they are tank engines applied to construction instead of destruction. Normally they will operate under better service conditions than the tank engine, for they can be ventilated more readily.

The average reconstruction job can be regarded from two angles:

1 — Preparation and
2 — Finishing.

Before any finishing work can be done the power shovel, bulldozer or some other of the materials handling equipment already mentioned must go in and remove excess material, do a backfilling job or grade the surface. Then the finishing machinery such as the scraper, concrete mixer and roller can do their work.

The design, function and lubrication of the power shovel has been discussed in a comparatively recent issue of LUBRICATION.*

FEATURES OF THE BULLDOZER

The bulldozer is as versatile in reconstruction and earth moving maneuvers as the jeep is in military service. It can push around several yards of material with seemingly no effect regardless of whether this constitutes back-fill for a bomb crater or shoulder-widening on a roadway. At the same time it can do a good leveling and scraping job in preparing the base for asphalt surfacing, concrete or road rolling.

The reason for this versatility and power obviously is centered in the power plant and tractive mechanism. In reality the bulldozer is a tractor mounted on caterpillar treads, powered by a heavy duty internal combustion engine. Correlated with these mechanisms are numerous precision bearings, finely cut gears and lubricating systems designed to give maximum protection to the moving parts in the most gruelling service. Quite obviously the lubricating system may spell the difference between success or failure, regardless of the nicety of the working parts. All the fine toolwork may be offset if lubricants cannot function effectually, or if the lubricating system does not prevent contamination.

The Engine

The bulldozer presented an ideal vehicle for the heavy duty tractor engine. The adaptability of this

*May 1943—Earth Moving and Open Pit Mining.

type of power plant extended materially the usefulness and field of service of virtually every type of earth moving machine. The story of the heavy duty engine has been told and re-told; its design is as familiar to the progressive engine mechanic as that of the engine in his car; its lubrication has been equally as forcibly presented.*

It remains but to stress the importance of considering lubrication and the selection of the lubricating oils with respect to the bearing materials.

TRENCHING OR DITCH DIGGING

The most widely known trench of the present war-era is the trench which had to be dug to enable laying of the "Big Inch" oil pipe line from Longview, Texas, to the Atlantic Seaboard, over thirteen hundred miles of trench, some three feet wide and four feet deep. Figured in yardage this meant approximately three million cubic yards of material handled by machine which otherwise would have required untold thousands of man-hours for removal and disposal.

The ditcher or trenching machine is a unique combination of a tractor and bucket conveyor. It operates in a manner somewhat similar to a power shovel in performing its function of linear excavation.

Ditching machines are most commonly found in railroad service for digging drainage ditches of varying depth, adjacent to the roadbed and track. In this service they are equipped with flanged wheels so as to move along the tracks.

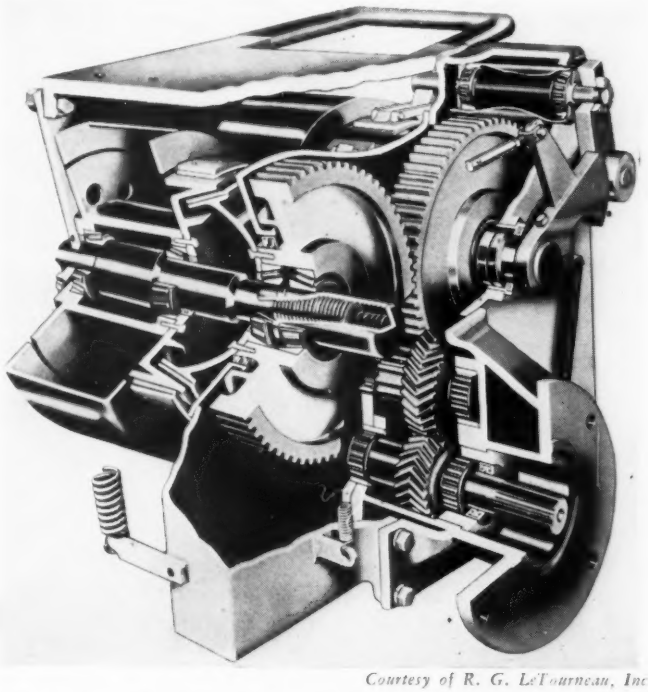
The trenching machine, on the other hand, is more of a general utility device designed for excavating by means of an endless-chain bucket device or a digging wheel. This machine is especially adaptable to street work in digging and disposal of earth preparatory to the laying of water, sewer or gas mains, or in oil pipe line service.

The general construction of these machines is quite similar consisting of the power plant which may involve steam or internal combustion engine power, with suitable gearing mounted on a rigid frame. According to the design, it may be propelled by a full caterpillar tractor tread or by a half-track assembly with the tractor treads as the powered elements.

In digging operation a trenching machine straddles the trench line and advances accordingly as the excavator does its work. This latter, in the ladder or endless chain bucket type of machine consists of a series of buckets attached to a continuous elevator or endless chain working in conjunction with a disposal conveyor. The wheel type of excavator carries an internal gear of varying size, equipped with buckets or digging blades set equidistant on the rim, and driven by a suitable pinion and chain connection from the power plant. As the machine advances and the wheel revolves, the blades dig into the earth, which is carried up and dropped onto a right angular disposal conveyor. The power shovel also can be operated as a trenching machine, by using a reversed bucket or hoe to drag the material from the trench.

DRAGLINE EXCAVATING

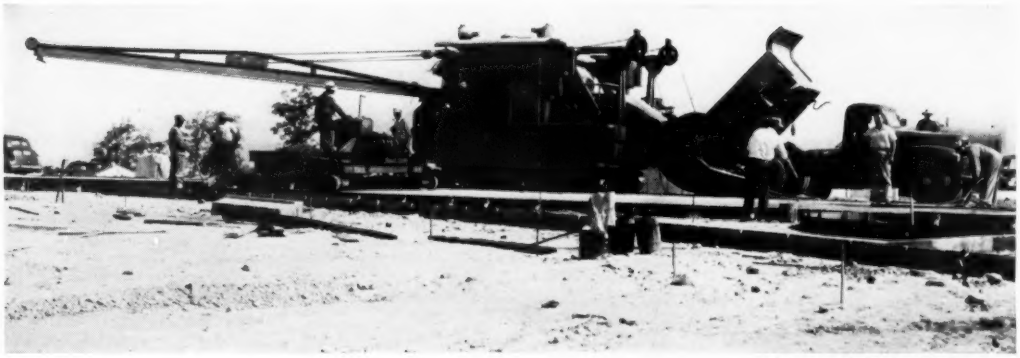
Skimming or scraping of rough materials can be done by an adaptation of the power shovel known as a dragline excavator. Such a machine is quite similar to the power shovel with the power plant, boom and controlling mechanisms mounted on a revolving turntable. The boom is usually longer, however, than the shovel boom and carries a ditcher or scraper bucket controlled by draglines or cables.



Courtesy of R. G. LeTourneau, Inc.

Fig. 2—Cutaway view of a LeTourneau Model T power control unit. This unit mounts on the rear of the tractor or Tournapull and transmits engine power to the cable to operate the earth moving or construction equipment.

*Heavy Duty Detergent Type Engine Oils LUBRICATION, Nov. 1943.



Courtesy of Chain Belt Company

Fig. 3—A Rex concrete mixer in paving service. Note length of the distributing arm.

In operation the bucket is raised to the required height by the hoisting engine, swung over the area to be excavated and dropped or thrown (according to the skill of the operator) to the desired location. By taking up on the dragline the bucket is filled by dragging through the material, after which it is raised and swung to the point of disposal.

Back-Filling Equipment

A back-filling machine is used for the re-handling of excavated material as is necessary when trenches or ditches are to be filled in. Usually a back-filler is built like a small dragline excavator, being fitted with a scoop or scraper controller by a boom, dragline and winch. This enables the operator to drag the material from the dump back into the trench as desired. Back fillers may be equipped with propelling treads of the caterpillar traction type, or a combination of broad rim wheels and tractors like a half track.

CONCRETE MIXING MACHINERY

On any construction or reconstruction job where concrete structures or pavements are required the concrete mixer is the key machine. The rate of concrete production controls the progress of the work. Accordingly, the operators should be careful to watch for the development of conditions traceable to faulty lubrication which might cause break-down due to serious wearing of gears, overheated bearings or engine troubles.

Concrete mixers receive very rough treatment and unavoidable neglect often may prevail. Also, there is always a certain amount of dust around the bearings, gear teeth or other operating mechanisms. Dust cannot be eliminated nor can one insure against careless workmen or the weather, but a form of practical insurance can be applied in the shape of proper and sufficient lubrication which will effectively diminish the detrimental effects of those damaging factors.

Mixing is usually carried out in some form of cylindrical or conical shaped rotating drum, box or trough-shaped container, which is generally fitted with suitable mixing blades or paddles.

Mechanical mixers of the drum type with horizontal axes are all essentially alike; they involve practically the same type of mechanism being operated by either a gasoline engine, a small single cylinder vertical steam engine or an electric motor.

According to design, mixers will vary as to manner of discharge, i.e., whether from the side or end; the manner of propulsion, i.e., whether stationary, self-propelled or portable; and the method of charging, i.e., by gravity, power conveyor, or hand labor. Stationary and portable mixers are suited for foundation and building construction work, while self-propelled machines are favored for roadway paving, or airport runways. The manner of charging and discharge depends upon the extent of the job. Power charging with a batch discharge from the side of the drum is widely preferred due to the resultant steadiness of production and uniformity of concrete.

The mixer drums, are, in general, rotated by some form of gear mechanism or chain drive. In usual construction one or two racks or sprocket wheels with suitable roller runways on either side of the teeth, are fitted circumferencially around the drum. The racks engage with suitable driving pinions; or, the sprocket wheels with driving chains, as the case may be, which are operated directly from the power plant. Certain types of mixers have an added refinement in that they are built so as to tilt forward when discharge is desired. Tilting mixers are useful where it is desirable to discharge the entire contents of the drum as a batch into some form of bucket or chute.

The manner of placing the concrete is also of interest. Dependent upon the magnitude of the work the material either can be discharged directly into some container such as a wheel barrow, hopper, or bucket; or else a jib and bucket system may be employed, the job being capable of swinging across

the width of the work and inclining to a certain extent when necessary. The travel of the bucket on the jib is controlled as desired by wire ropes and a suitable hoisting mechanism. This latter method is much used in highway and airport construction work. Where the material is to be handled over any extensive distance, it can be discharged into a gravity chute or conveyor.

FINISHING THE JOB

The finishing machinery required for reconstruction work will depend materially upon the nature of the job. In airport runway and highway construction, after the bulldozer, scraper or dragline have developed a relatively smooth surface and brought the area to the desired grade, the problem is to spread and roll the foundation, then to apply the top finish. This latter may be concrete, asphalt or simply a coating of crushed stone or gravel.

The Scarifier and Grader

The grading of any roadbed will naturally depend upon the nature of the soil, the amount of backfill, how heavy the traffic will be and the type of foundation and surface that is to be used. Very often scarification will be necessary in some places in order to loosen the hard earth or to smooth out a relatively rough subgrade.

The modern scarifier and grader in conjunction with the power shovel and bulldozer eliminate ridges whenever requisite, or fill in minor depressions with ease. These machines are subject to exceedingly rough service and strain so they are built to exacting specifications. All bearings and gears are of the best materials and carefully aligned in order to insure a basis for effective lubrication. Any failure due to burned out bearings or other defects caused by faulty lubrication can often delay the entire job, inasmuch as frequently the concrete mixer, road roller and surfacer follow up closely.

The basic principle of the road scarifier, grader or scraper involves a draw-bar machine. At first it was a detachable unit adapted either to horse or tractor power. More recently self propulsion has been perfected which embodies not only a convertible scarifier-grader, but oftentimes a road roller as well.

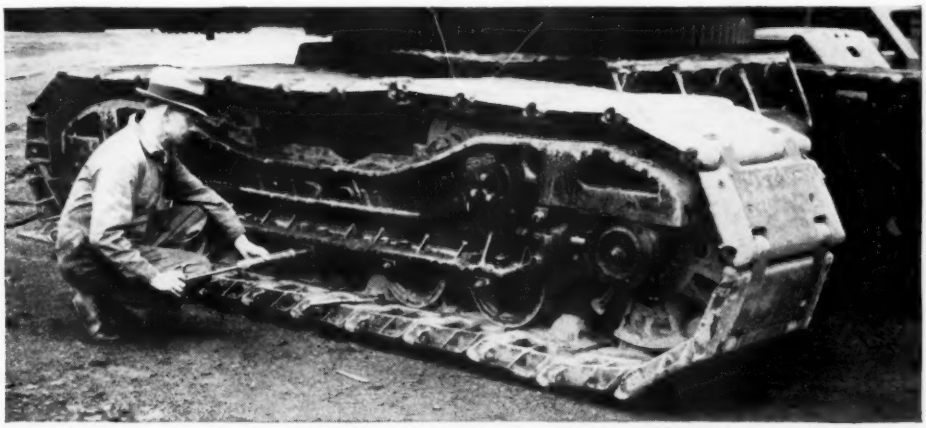
The most important details on a scarifier or grader are the lifting and lowering devices which control the blades or teeth. The lifting arms on certain draw-bar machines therefore, are equipped with roller bearings in order to reduce friction as much as possible. Some builders of convertible road machinery of the roller-scarifier type also provide air compressors in order to operate the scarifying rig by air pressure. In general two cylinders are installed per machine for the distribution of pressure to the teeth. As a result, power application is evenly distributed and the teeth are forced rigidly into the roadway at a constant depth. At the same time, pressure can be evenly released when obstructions are encountered.

Road Rollers

The road roller is an important factor in the building of a good asphalt highway. Unless there is sufficient weight to adequately press the materials into place, and a power plant capable of operating the roller, regardless of the grade or other conditions, the roadway will suffer accordingly. The power plant is the controlling feature in the roller. Steam, gasoline and kerosene engines were at first very largely used. Today, however, the heavy duty internal combustion engine is preferred.

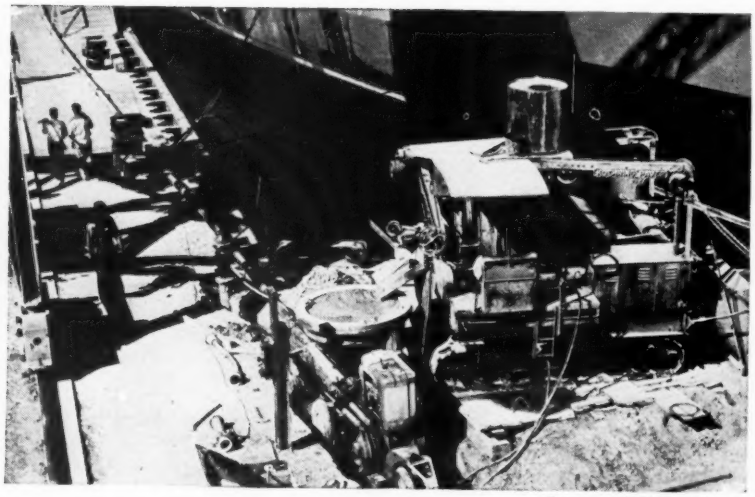
Road Surfacing and Finishing Machinery

Concrete highway construction requires the use



Courtesy of The Marion Steam Shovel Company

Fig. 4—Lubricating the track rollers on a Marion shovel. The necessary fittings are protected to keep out dirt and prevent damage.



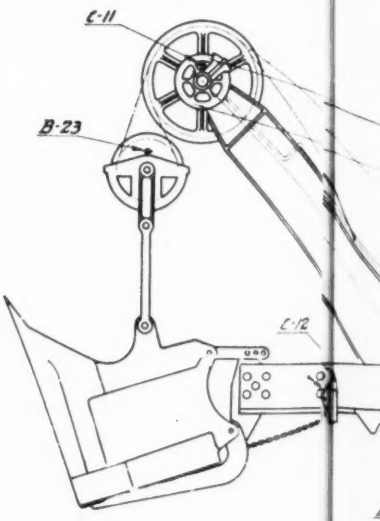
Courtesy of Chain Belt Co.

Fig. 1—A Rex 160 Pumpcrete placing concrete ballast in the bilge of a cargo ship. Even distribution in small partitioned compartments can be done satisfactorily by this method of handling concrete.

Fig. 4—The use of gantry cranes in

Courtesy of R. G. LeTourneau, Inc.

Fig. 2—A LeTourneau Bulldozer and Model L Carryall Scraper building a mountain road.



Courtesy of Western-Austin Road Machinery Company

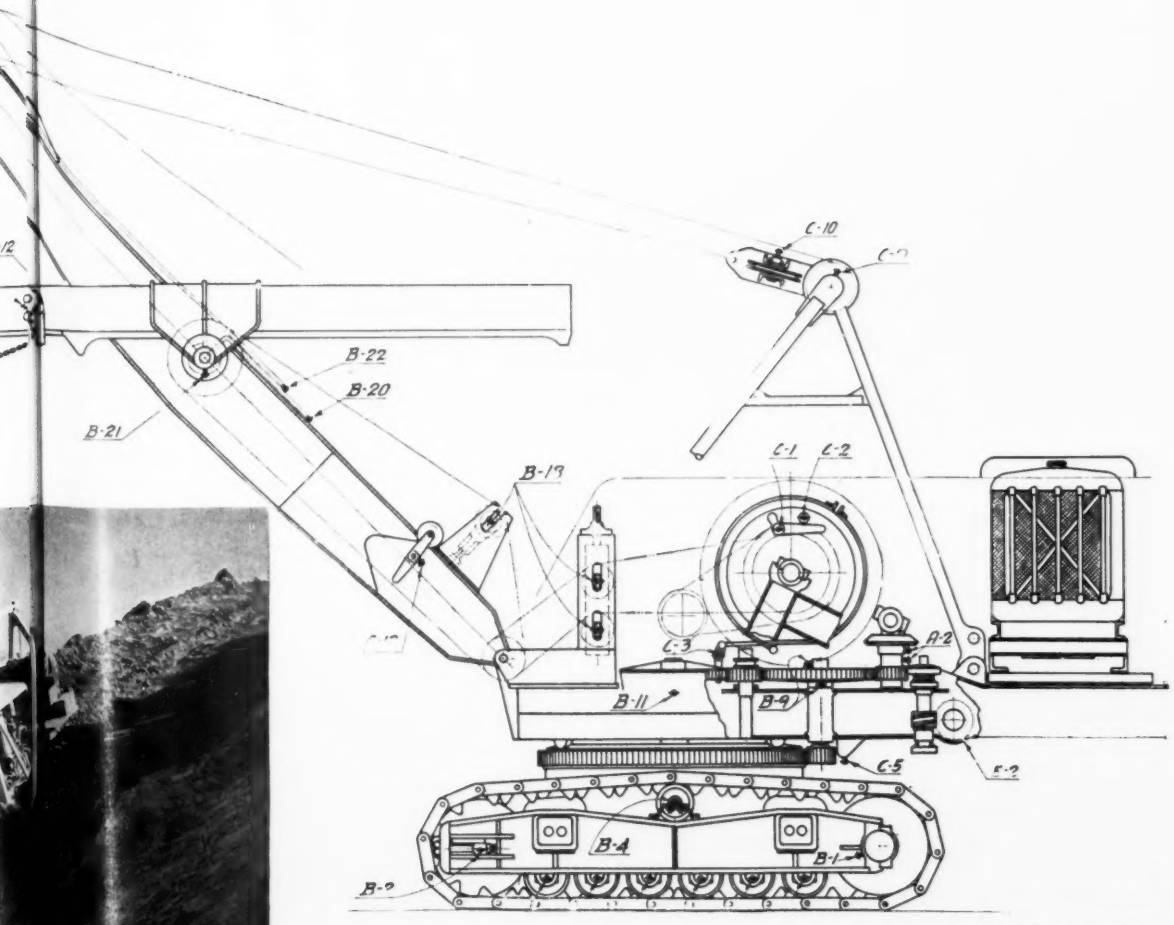
Fig. 3—How the Motor-Grader functions in building up and widening a road surface.

Fig. 6—How the Bulldozer can be used for leveling and pushin shovel for loading.

Courtesy of American Hoist and Derrick Company
...ntry cranes in large construction work.

Courtesy of The Marion Steam Shovel Company

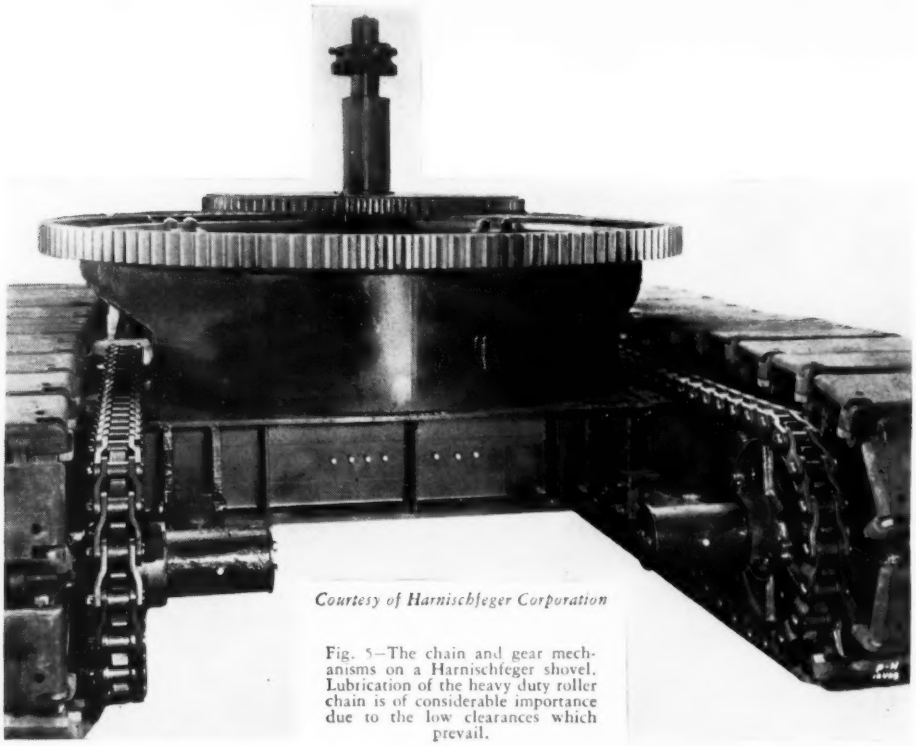
Fig. 5—The Marion type 362 Dragline showing length of boom and comparative swing.



Courtesy of Link-Belt Speeder Corp.

Fig. 7—Lubrication chart for the Link-Belt Speeder. Points indicated require lubrication according to manufacturers' chart and recommendations.

...urtesy of R. G. LeTourneau, Inc.
...veling and pushing dirt down-hill to a



Courtesy of Harnischfeger Corporation

Fig. 5—The chain and gear mechanisms on a Harnischfeger shovel. Lubrication of the heavy duty roller chain is of considerable importance due to the low clearances which prevail.

of a surface tamping and finishing machine which will thoroughly pack the material and form it to any desired crown or width. For this purpose a pressure beam device which travels along the sideforms is usually employed. Machines of this nature travel ahead at a rate of about five feet per minute. Two beams or tamping members are installed on machines of this type. The leading beam serves as a rough tamper, forcing the material ahead of it and into a compact bed by downward pressure. The follow-up or smoothing beam kneads the mass into the desired form and contact by a reciprocating or sawing action across the roadway. On a concrete surface this action effectively works water globules and air up from the material. On some machines of this type the smoothing beam finishes the surface, on others a finishing belt is used to remove excess water.

The tamping members are operated by an internal combustion engine mounted on the machine, power being transmitted through suitable gearing. Reciprocating motion is attained by link and rocker mechanisms.

HEAVY DUTY LUBRICATION

Aside from the power plant, lubrication of construction or contractors machinery requires primary consideration of gearing and heavy-duty bearings. In other words, parts, which if worn to excess may cause the machines to operate inefficiently or require replacement of "hard-to-get" materials.

Power Drives and Speed Reduction Gears

Lubrication of power transmission drives and speed reduction gears on construction machinery may always present a potential problem due to load conditions and frequently exposure. On any exposed gear there is possibility of the lubricant being contaminated with dust or dirt to increase the amount of wear and alter the pitch line.

Pressure also requires consideration in many such gear installations. As a general rule the tooth pressures will be comparatively high, due to the small areas of contact. The more accurately the gears have been cut the more intense will be the unit pressure, inasmuch as line contact will more nearly prevail. Gear tooth pressures change constantly as opposing teeth mesh with each other. This causes change in the direction of application of the load. As long as rolling motion predominates, the effect on the structure of the teeth will not be serious. When wear occurs, however, there will be a tendency for the motion between the teeth to become sliding instead of rolling. Then a certain amount of grinding occurs between the teeth to cause wear, especially if lubrication is not maintained in an effective manner.

To offset this a gear lubricant should possess a high degree of lubricating ability. It was realization of this fact that prompted such intensive study of gear lubricants during the past decade and resulted in development of both straight mineral and E.P. products of vastly improved film strength commensurate with the viscosity or fluidity. This enabled gear engineers in turn to adopt more precise methods of cutting and to some extent to produce gears of higher load-carrying capacity for the same tooth area.

Temperature of course affects the fluidity although in the normal operation of construction machinery, gears will function at atmospheric temperature. As a result, there will be but little possibility of the gear lubricant being reduced in viscosity by abnormal heat. The effect which low temperature may have upon a gear lubricant in service, however, requires more consideration. Certain grades of lubricants will have a tendency to congeal to such an extent as to become brittle and crack. If a lubricant has been properly refined, however, there should be little danger of this occurring.

The average range in viscosity for service on exposed gears will vary from approximately 1000 to 2000 seconds Saybolt at 210 degrees Fahr., the lubricant being chosen to meet the operating temperatures and size of gears. Where gears are enclosed a more fluid lubricant is advisable. The same holds true for the average silent chain drive where comparatively low clearances prevail between the link mechanisms. The lubricant, of course, must be capable of penetrating to all surfaces of contact between these parts; otherwise, abnormal wear may develop. Here a lubricant of about the same viscosity as a heavy steam cylinder oil, i.e., in the neighborhood of 150 to 200 seconds Saybolt at 210 Fahr., has proved satisfactory.

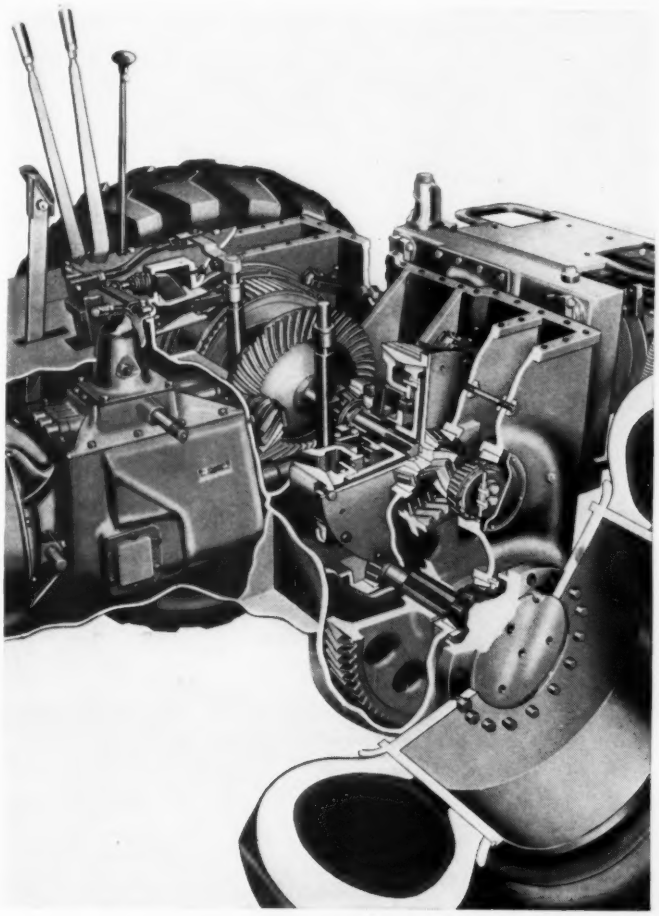
Methods of Handling Lubricants

Along with the type and extent of refinement of the lubricants employed, the means whereby they are applied or distributed has a marked effect upon their ability to insure efficient and economical gear operation. Obviously, even the best of lubricants may function ineffectively if they are unable to cover the contact surfaces of the teeth.

Probably more failures and complaints arise from ineffectual lubrication through misusage of lubricants than from any average operating condition. In many cases these can be traced to ignorance; in others, lack of appreciation of the lubricating requirements. With an understanding of these latter, and knowledge of the lubricants which are available, protection of gears in construction work should be materially simplified. Each operator, however, must study his own particular operating conditions, then use his lubricants intelligently, in accordance with the recommendations of the builders of his machinery and the oil company from whom he purchases. Makeshift or obsolete ideas may have been permissible in the past; today, the necessity for maximum production demands the adoption of the most modern means of lubrication, in the interests of continued and efficient operation.

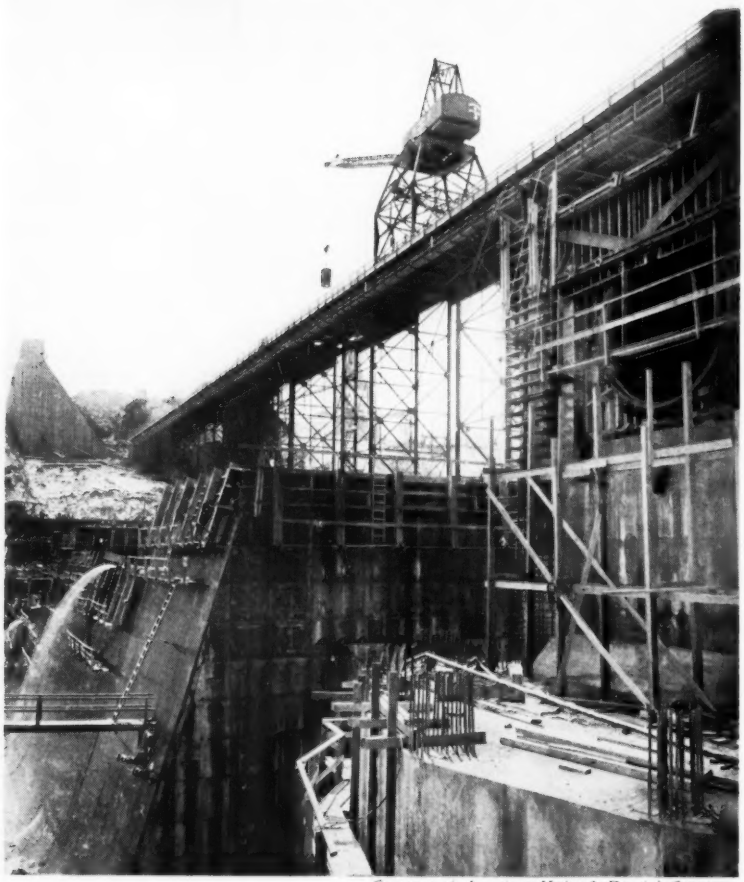
Indication of Wear

Wear in gears and driving chains is indicated



Courtesy of R. G. LeTourneau, Inc.

Fig. 6—Cutaway view of final drive for a super C Tournapull.



Courtesy of American Hoist & Derrick Company

Fig. 7—Show an "American Revolver" gantry mounted crane on large construction work.

by excessive noise. As a general rule, there will be better ventilation than prevails with the average bearing. In consequence, increase in operating temperatures usually will not be as marked even in extreme cases of faulty lubrication of gear teeth or chain link connections, for radiation will serve as an effective means of temperature reduction.

Development of continued, noisy, clanking operation, is a decidedly positive indication that a gear or chain lubricant is not functioning effectually as a preventive of metallic contact and solid friction.

Fortunately there are regular periods over which a gear lubricant is inactive, for actual contact between the teeth only occurs when they are in mesh. To a somewhat less extent the load imposed upon a chain link connection will also be decreased during the period of slack operation.

Chain lubrication, however, more nearly approaches bearing lubrication in the requirements which will be imposed upon the lubricants. Yet, there is more chance for lubricant to be thrown off from a chain link than from the average bearing, for even though bearings themselves may be subject to rotary or reciprocating motion, this will not be as severe as the action of centrifugal force on a driving chain. This effect may be most serious in the lubrication of high speed exposed or semi-enclosed chains; it will be greatest during the period of bending, as the chains pass over the sprockets. At such times any lubricant on the outside surface of a chain may be thrown off, although this will depend upon the adhesive ability of the lubricant and the peripheral or surface speed of the sprockets.

All this calls for:

1. The selection of a lubricant of adequate viscosity and adhesive ability, commensurate with the manner of housing and the method of application, and
2. Application of this lubricant over the inner or more active wearing surfaces, in order to insure as complete penetration as possible to the teeth or link connections before the lubricant has a chance to work its way to the outside surfaces from which it may be thrown off.

These considerations apply more strictly to the exposed or semi-enclosed drive, wherein there is but little or no provision for automatic lubrication. Where a driving chain or gear set receives a constant supply of lubricant as in the timing gear drive in an automotive engine, or those enclosed industrial chains which are fitted with means for circulation of oil from a base reservoir, maintenance of lubrication is more positive, and requires only an adequate supply of properly refined gear lubricant.

HEAVY DUTY BEARINGS

Alignment is most important in heavy duty bearing operation. Theoretically line contact prevails in a heavy duty roller bearing. Actually, however, the potential contact surface for such a bearing is rectangular, though of considerably less area than in a sleeve bearing. This contact in a roller bearing especially must be maintained without deviation,

for skewing of a roller on a turntable or track roll assembly, for example, may throw the entire bearing out of line,to result in uneven load distribution and wear. In other words, just as in a well-designed sleeve bearing, the axes of the bearing elements must be in the same plane as the axis of the rotating shaft.

Proper guiding has been found to be the most effective way to keep rollers from skewing; this is a function of the guide flange. As rollers are increased in ratio of length to diameter guiding may become more difficult. At the same time while one objective may be attained the problem is aggravated by the sliding motion which is developed between the ends of the rollers and the end plates or race flanges. Continuous renewal of the lubricating film is necessary to prevent actual steel-to-steel contact at this point.

Function of the Lubricant

The lubricant serves a number of purposes in a heavy duty bearing.

(1) It must protect the component parts of the bearing against corrosion.

(2) It must assist the seal in preventing entry of water or dirt, and the resultant abrasive or corrosive effect on the bearing surfaces.

(3) It must be a good heat exchange medium to aid in bearing cooling.

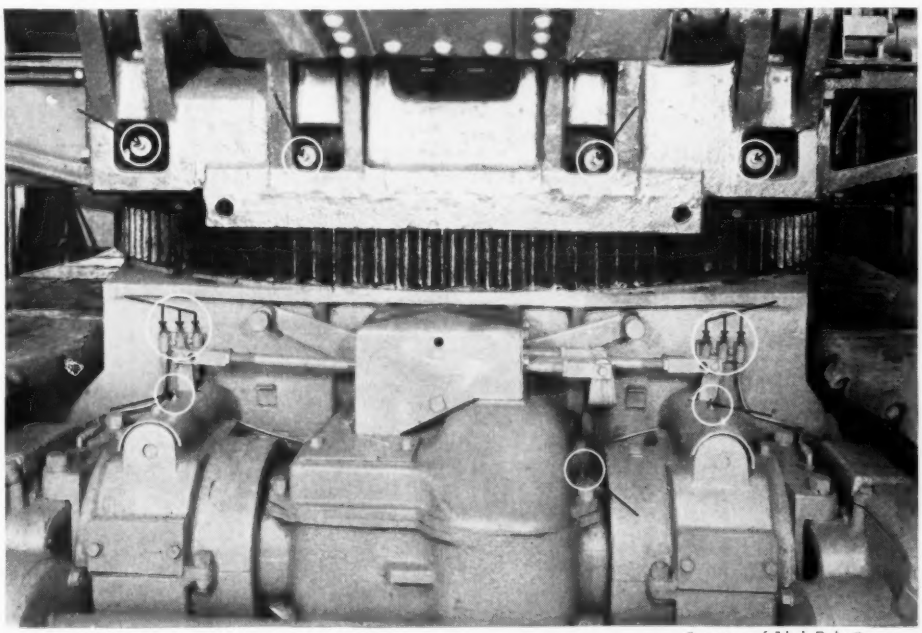
(4) It must function as a lubricant to enable free rolling of the rollers in a roller bearing, and sliding between the rubbing surfaces of the shoulders and rollers.

A lubricant which trains freely with the moving parts at the prevailing operating temperatures will meet these requirements most effectually. At the same time the lubricant must channel sufficiently so that actual churning does not occur. Excessive churning will increase the power consumption through internal resistance within the lubricant itself. This frictional effect leads to heat development which may easily build up the bearing temperature beyond the cooling ability of the lubricant, then trouble may be impending.

Prevention of Wear

The seal is an important adjunct to cleanliness. If abrasive foreign matter is kept out of the bearing, wear will be reduced, especially if clean, dirt-free lubricants are used, and protected from contamination.

On the other hand, if abrasive particles are present rough rolling of the bearing will result. When this occurs in a freshly lubricated element, it signifies abrasion. At first this may be very slight, and may not be noticeable. But abrasion and wear are going on just the same, until, dependent upon the amount of dirt, the speed and the size of the bear-



Courtesy of Link-Belt Company

Fig. 8—A view directly under the shovel boom on a Link-Belt crawler gas shovel. Circles and arrows indicate pressure gun fittings. The lower frame gears are enclosed in substantial housings and run in oil

ing, loose rolling or chattering will develop. At the same time, the heat at the contact points may be so high as to assist in oxidation-breakdown of the lubricant. Then gums and lacquers may form. Thorough cleaning, drying and relubrication of the bearing parts before wear has occurred to excess is the best preventive against further difficulty.

Nature of the Lubricant

Lubricating oils or greases for heavy-duty bearing service accordingly must possess very definite characteristics. These features must be considered according to the nature of the service, likewise the means provided for relubrication.

Greases suitable for heavy duty bearings are studied in accordance with the actual lubricating requirements, also with respect to the ability of the lubricating systems to handle the finished grease under the prevailing operating temperatures. In other words, certain definite pressures are available for grease distribution through the lubricating system, according to the design of the pressure pumps.

Accordingly the petroleum refiner begins with careful selection of the fatty oil and alkali which are used to make the soap base; then a range of straight mineral oil viscosities is selected which are best adapted to the prevailing temperature conditions. All these basic materials must be of a high degree of purity and free from contaminating foreign matter. They must then be combined so that the finished grease will be uniform in composition and texture, resistant to chemical breakdown, not too water-soluble, and structurally capable of being pumped at low temperatures.

Water and heat must always be studied when planning the manufacturing procedure for a grease, since the effect of water upon certain soap stocks, and the viscosity-reducing effect of heat on the viscosity of mineral oils may affect materially the lubricating ability. Lime soap is insoluble in water, so it is widely used where an excess of water may be present. Where soda soap or mixed (lime-soda) base greases are involved, the solubility tendency will increase with the temperature of the water.

Methods of Lubrication

Pressure grease lubrication by positive delivery of measured quantities of grease at periodic intervals is customary on mobile machinery such as the bulldozer, power shovel, roller and concrete mixer. The equipment has been specifically designed to prevent entry of non-lubricating foreign matter to assure economy of lubricants and to reduce the hazards in handling, filling and control.

CONCLUSION

Modern highway construction has progressed remarkably since the days of the split-log drag. Mass production has entered the field of construction equally as prominently as it has revolutionized the manufacturing of everything else. The demands of the motorist have been heavy; truck transportation and aviation called for construction of a network of national state and municipal highways, bridge revision and airport design. All taxed the science of the civil engineer and the resources of the contractor. But the modern power shovel, drag-line, bulldozer, concrete mixer, road scraper, grader and power roller, etc., effectively solved the problem.

Construction machinery is subject to most severe service and operates under most difficult and injurious conditions. Exposure to the weather and frequent contact with mud, dust, abrasive and corrosive materials cause depreciation of the working parts that is oftentimes far above normal. To counteract the injurious effects of such exposure, machinery of this type is rigid in design and construction. But regardless of the mechanical features, wear will occur relatively rapidly unless lubrication is effectually maintained. Therefore, lubrication in the field of construction engineering is a paramount feature if cylinders and bearings are to resist scoring in event of entry of abrasive particles of foreign matter; if gears are to operate properly without abnormal wear in the presence of corrosive fumes or dust; and if wire ropes and chains are to function safely day after day without the possibility of broken or rusted strands or links.

Lubrication of course, must be studied with due regard for the exposed conditions under which such machines may operate. Protection of lubricants under such conditions is as important as protection of the working parts. It is imperative that they be capable of functioning effectively regardless of weather and temperature fluctuation. The probability of water being present in sufficient quantity on the average construction job to reach to certain of the moving parts of some machines, requires full appreciation of the detrimental effects which may result.

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TEXACO LUBRICANTS FOR CONSTRUCTION MACHINERY

THE POWER PLANT

DIESEL ENGINES (According to operating conditions, engine requirements and manufacturers' recommendations)	See Texaco Lubrication Chart
GASOLINE ENGINES (According to manufacturers' recommendations)	See Texaco Lubrication Chart
STEAM CYLINDERS	
Saturated Steam (above 150 lbs.)	Texaco Cavis Cylinder Oil or Texaco 650 T Cylinder Oil
Saturated Steam (below 150 lbs.)	Texaco Pinnacle Cylinder Oil or Honor Cylinder Oil, or Texaco Draco Cylinder Oil
AIR COMPRESSORS	
Cylinders	Havoline or Texaco Motor Oil S.A.E. 10 or 20 or Texaco Cetus Oil or Alcaid Oil
External Parts	Texaco Aleph Oil or Altair Oil

BEARINGS

PLAIN BEARINGS	
Oil Lubricated	Havoline or Texaco Motor Oil S.A.E. 20 or 30 or Texaco Aleph Oil or Altair Oil
PLAIN BEARINGS	
Grease Lubricated	Texaco Cup Grease or Texaco Marfak
ROLLER BEARINGS	Texaco Marfak or Texaco Regal Starfak No. 2
CHASSIS PARTS	Texaco Marfak or Texaco Chassis Lubricant

GEARS AND CHAINS

TRANSMISSIONS AND DIFFERENTIALS	Texaco Thuban or Texaco Gear Lubricants (to conform with operating temperatures)
EXPOSED OR SEMI-ENCLOSED	Texaco Crater (of a grade commensurate with type of housing and operating temperature)*

WIRE ROPE: Use Texaco Crater for strand protection and core preservation in service. The grade to be commensurate with operating conditions and means available for application.*

* See Texaco Crater Booklet.

Tokio Trail

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